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Technical Report ARWEC-TR-00002

DOWNLOADED SUPPLEMENTARY CHARGES FROM THE DEMILITARIZATION OF HIGH EXPLOSIVE LOADED MUNITIONS TESTING AND EVALUATION RESULTS

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July 2000

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13. SUPPLEMENTARY NOTES

14. ABSTRACT

This report describes the results of testing and evaluation of supplementary charges that were previously downloaded from demilitarization of high explosive loaded munitions.

Five tests were selected to obtain performance and sensitivity data.

The objective of this testing and evaluation was to confirm that the performance of downloaded supplementary charges has not been affected by aging and exposure to environmental elements. Samples of supplementary charges manufactured in 1997 were tested for direct comparison with the charges produced in the 1970's.

15. SUBJECT TERMS

Supplementary charge Demilitarization Reutilization Recycle TNT

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INTRODUCTION

Background

The U.S. Army Depots have in their inventories in excess of 1,000,000 supplementary charges that were downloaded from high explosive (HE) loaded munitions during the demilitarization operations. Supplementary charges consist of 0.30 lb of pressed Trinitrotoluene (TNT) within an aluminum cylindrical shaped housing. Supplementary charges are used in HE loaded projectiles as part of the detonation process. This office proposed using these downloaded supplementary charges for current and future production of medium and large caliber projectiles requiring the use of supplementary charges. The downloaded supplementary charges were originally manufactured to the same requirements specified in the technical data packages for all artillery munitions and are therefore suitable for reuse.

To address the TNT dusting problems that were identified with recently manufactured supplementary charges, procedures were developed to modify the supplementary charges at the U.S. Army Depots in order to ensure that their integrity remains intact during rough handling, shipping, etc. The modification consists of installing the pad on the crimped end of the supplementary charge (figs. 1 and 2 for comparison) using an RTV seal. This modification was approved and will be required for any future production of supplementary charges. In a memorandum dated 29 August 1996, the Assistant Secretary of the Army established a policy emphasizing the importance of Resource Recovery and Reuse of demilitarized munitions/components to the greatest extent possible in order to reduce demilitarization costs and avoid the harmful effects of open burning/open detonation practices. The effort will have a positive effect toward achieving these goals and demonstrate that the Army has taken the lead in implementing this policy.

Program Objective

To perform a test and evaluation program that will confirm the performance of downloaded supplementary charges has not been affected by aging and exposure to environmental elements. Samples of supplementary charges manufactured in 1997 were also tested for direct comparison with the supplementary charges produced in the 1970's.

PROGRAM PLAN

To ensure that downloaded supplementary charges at U.S. Army Depots are acceptable for reuse, five tests were selected to obtain performance and sensitivity data. The five tests selected were large scale gap (LSG), thermal stability, vacuum thermal stability (VTS), differential scanning calorimeter (DSC), and moisture weight percent. Sixty downloaded supplementary charges that were manufactured in 1971 (fig. 3) were received at the U.S. Army Armament Research, Development and Engineering Center (ARDEC), Picatinny Arsenal, New Jersey from McAlester Army Ammunition Plant for performing the testing. Sixty additional supplementary charges that were manufactured in 1997 (fig. 4) were received from Iowa Army Ammunition Plant to use as control items for the testing.

A supplementary charge consists of an aluminum housing approximately 2 in. in diameter by 2.5 in. long. The aluminum housing contains two pressed TNT pellets (fig. 5) and a felt pad. In order to conduct the performance and sensitivity tests, the aluminum casing of the supplementary charges was cut open using a remote operated lathe and the pressed TNT pellets were removed. The TNT pellets were machined (fig. 6) to accommodate the steel tube used for the LSG test. A Wiley Mill was used to grind the TNT pellets into powder form in order to perform the VTS, DSC, and moisture weight percent tests.

Large Scale Gap Test

The LSG test is designed to give a measure of the performance and sensitivity of an explosive by subjecting a sample to the dynamic shock generated by a donor charge. The donor charge used for this test consisted of two pentolite pellets. The test is performed with a small gap between the donor charge and acceptor charge. The gap is created using 0.010-in. thick disc of cellulose acetate and 0.50- to 3-in. thick Lucite discs. Combinations of the discs are used to produce any desired gap in increments of 0.010 in. The machined TNT pellets are placed inside of a steel tube and the donor charge, which is set on top of an arrangement of gap discs, is placed on top of the steel tube (figs. 7 and 8). The assembly is then placed onto a 0.375-in. thick witness plate supported by steel blocks set 4 in. apart (fig. 9).

A gap of 1.5 in. was initially selected based on past LSG tests conducted on TNT at ARDEC. During the test, if the TNT pellets detonate causing a hole in the witness plate, it was considered a "go." The gap was then incrementally increased until the detonated TNT pellets did not yield a hole in the witness plate, considered a "no go." After the first no go subsequent tests are conducted until a go and no go have been obtained with a difference of only a 0.010 in. gap. Testing was completed with a total of 15 tests conducted.

Thermal Stability Test

Thermal stability testing is performed to determine the ability of energetic materials to retain properties such as detonation velocity and sensitivity after long periods of storage under adverse conditions. Samples of TNT are weighed and subjected to a temperature of 75°C for 48 hrs. A condition of volatility or decomposition exists if during the test, the sample exhibits a change in color, ignites, or explodes. After 48 hrs, the samples are again weighed and a condition of volatility or decomposition still exists if a measured loss of weight in excess of the weight due to moisture is detected.

Vacuum Thermal Stability Test (per MIL-STD-286C, Method 403.1.3)

The VTS test is performed to determine the stability of an energetic material on the basis of the volume of gas generated upon heating the sample under vacuum. Test samples of 5 g each of TNT were subjected to a temperature of 100°C and vacuum for 40 hrs. The volume of gas at standard temperature and pressure (STP) generated after the specified time was recorded as the test result.

Differential Scanning Calorimeter Test

The DSC test is a thermal technique used to analyze thermal behavior of a substance. A sample of the TNT explosive and an inert reference material are subjected to a precisely programmed temperature change. When a chemical or physical change results in the release or absorption of heat within a sample, thermal energy is added to either the sample or reference material in order to maintain the sample and reference at the same temperature. Due to the energy transferred being exactly equivalent in magnitude to the energy absorbed or evolved in the transition, the balancing energy yields a direct calorimetric measurement of the transition energy. This test provides an evaluation of the thermal compatibility and possible contamination.

Moisture Weight Percent (per MIL-STD-650, Method 101.4)

The moisture weight percent test was performed to measure the moisture content of the TNT explosive to determine if aging and exposure to the environment has caused the TNT to absorb moisture. The TNT samples consisted of approximately 8 to 10 g of explosive weighed to within 0.2 mg.

RESULTS OF TESTING AND EVALUATIONS

A summary of the test data obtained is provided in table I. Detailed test data is provided in the appendix.

Table 1

Summary of test data

Tests	Charge samples	
	Control item Lot DAZ97G001-002	Test item Lot LS-5-137
Large scale gap (LSG)	2.125 in.	2.105 in.
Thermal stability	0.2050 gm* @ 131.3664 gm	0.3989 gm* @ 140.1173 gm
Vacuum thermal stability (VTS)	Stable 0.23 mL gas @ STP**	Stable 0.23 mL gas @ STP**
Differential scanning calorimeter (DSC):		
Maximum exothermic temp (°C)	308.75	306.23
Melting point (°C)	81.62	81.93
Moisture weight percent	0.031 +/- 0.007	0.025 +/- 0.005

*TNT weight loss.
**Standard temperature and pressure.

The LSG test resulted in a difference of 0.02 in. in gap between lots, which indicates that the lots tested are identical within experimental error and are acceptable.

The thermal stability test resulted in lot DAZ97G001-002 having approximately 0.16% TNT weight loss and lot LS-5-137 approximately 0.28% TNT weight loss. Samples are within expected range from the loss of water content within the material. These readings are well within experimental error and considered stable.

The VTS test resulted in identical readings of 0.23 mL of gas evolved at STP for the control lot and the test lot. Both lots are considered stable.

The DSC test values for both maximum exothermic temperature and melting point are essentially identical for both samples within the experimental errors and are acceptable.

Moisture weight percentages in both samples are identical within the experimental errors and are well within the TNT specifications value (0.1% max).

CONCLUSIONS

Based on the results of the performance and sensitivity testing performed on the downloaded supplementary charges from the Army's Depot Plants, it was clearly demonstrated that the performance of these supplementary charges was not affected by aging and the surrounding environment. Control samples obtained from recently manufactured supplementary charges were also tested as standards for direct comparison with the downloaded supplementary charges and the results were equivalent in performance and sensitivity. As a minimum, the recycle criteria specifies that performance and sensitivity testing be conducted to confirm that any TNT manufactured in more than 10-yr intervals has not been affected due to aging or the environmental elements.

RECOMMENDATIONS

It was recommended that downloaded supplementary charges be used in current and future production of artillery projectiles. It should also be noted that by implementing this recommendation, current and future artillery production programs will be provided with high quality, low cost supplementary charges, which are equal in performance to those currently being produced.

Figure 1
Downloaded supplementary charge with felt pad on opposite side of disc/crimp interface

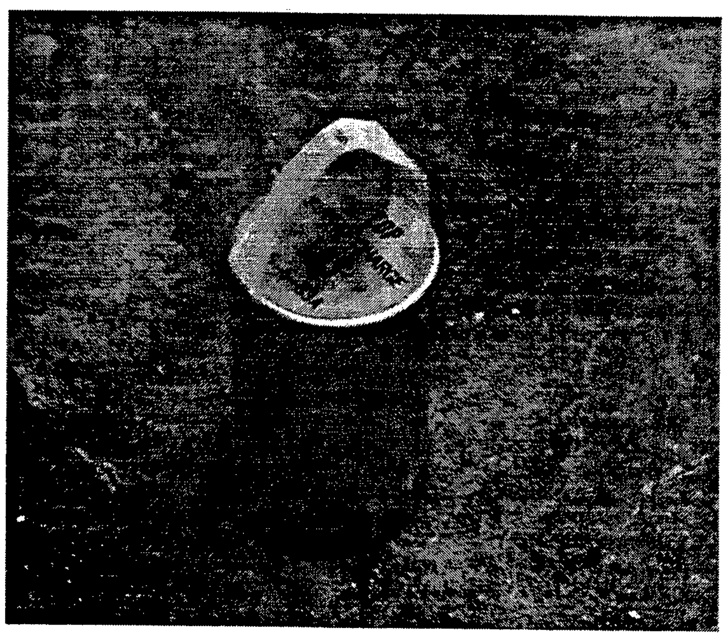


Figure 2
Modified supplementary charge with RTV and felt pad applied to disc/crimp interface

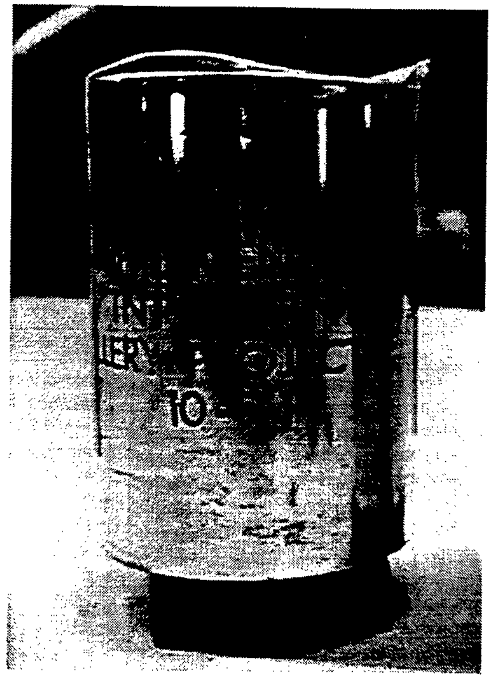
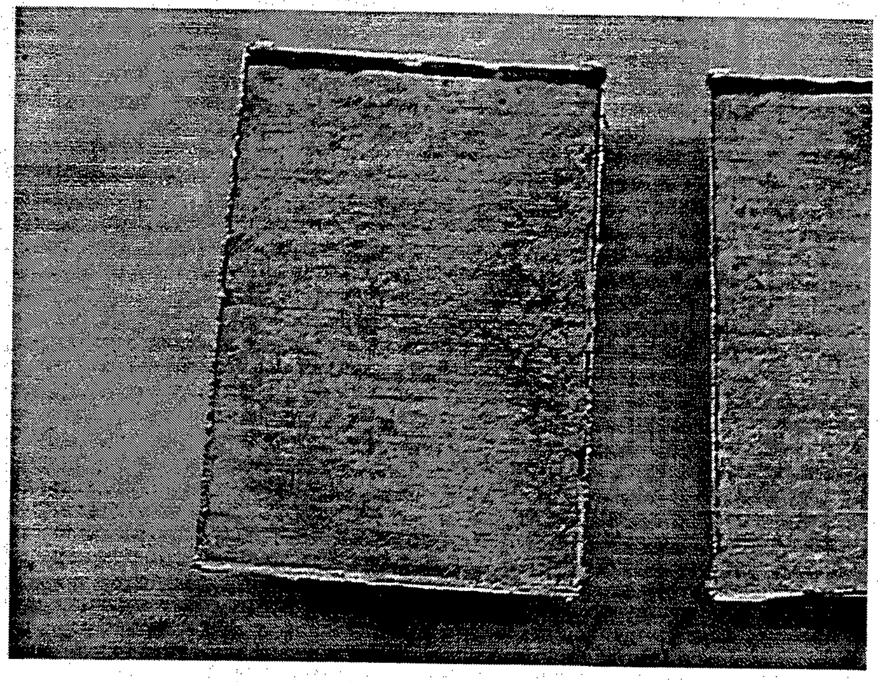


Figure 3
Downloaded supplementary charge manufactured 1971

Figure 4
Supplementary charge manufactured 1997



There are two pellets in each charge and a fine line can be seen between each pellet.

Figure 5
Supplementary charge cut in half

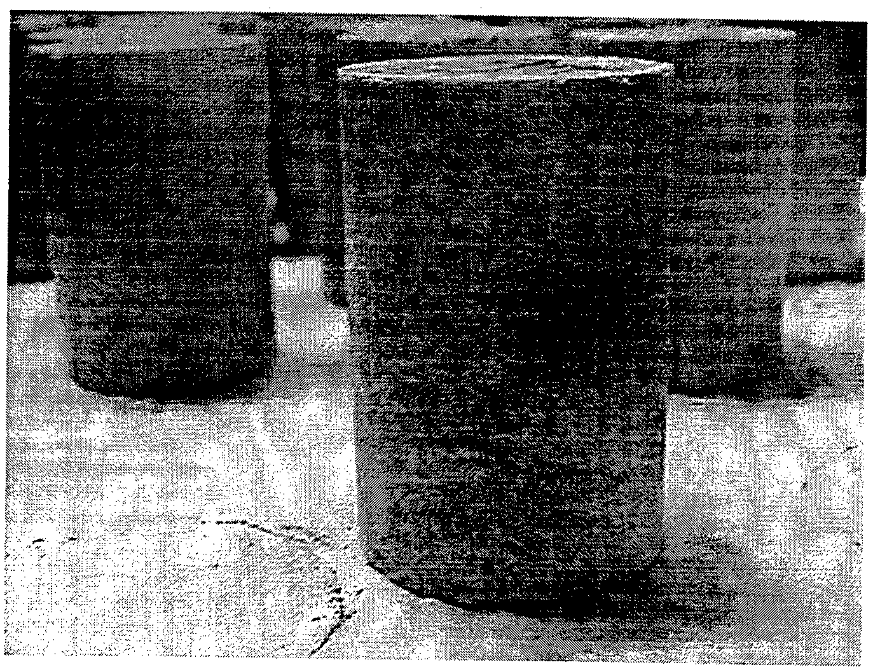


Figure 6
Two pellets removed from supplementary charges, machined to fit into the LSG test fixture (manufactured in 1971)

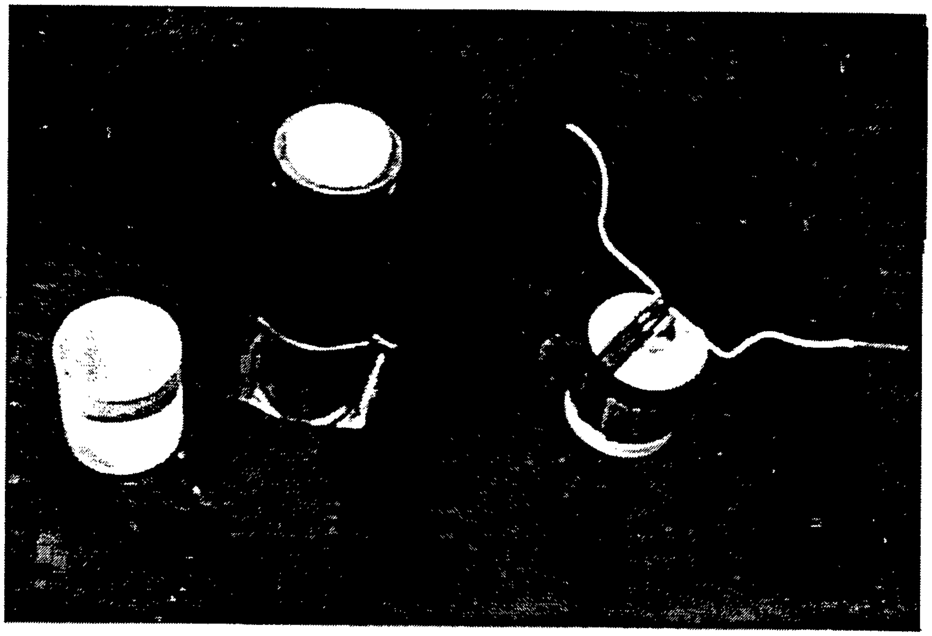


Figure 7
LSG test fixture consisting of the Lucite pellet (left), steel tube containing five TNT pellets (center), And pentolite pellet donor charge (right)

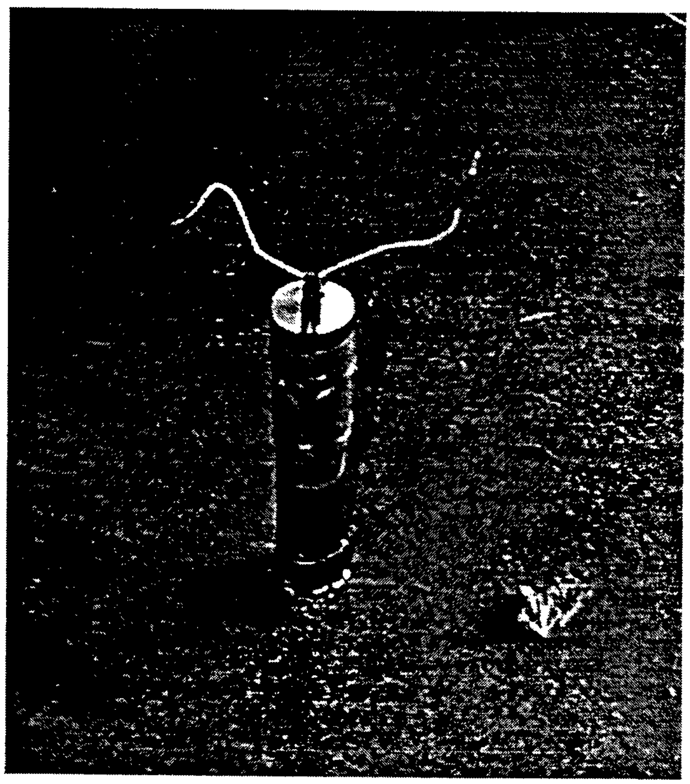


Figure 8
LSG test fixture fully assembled

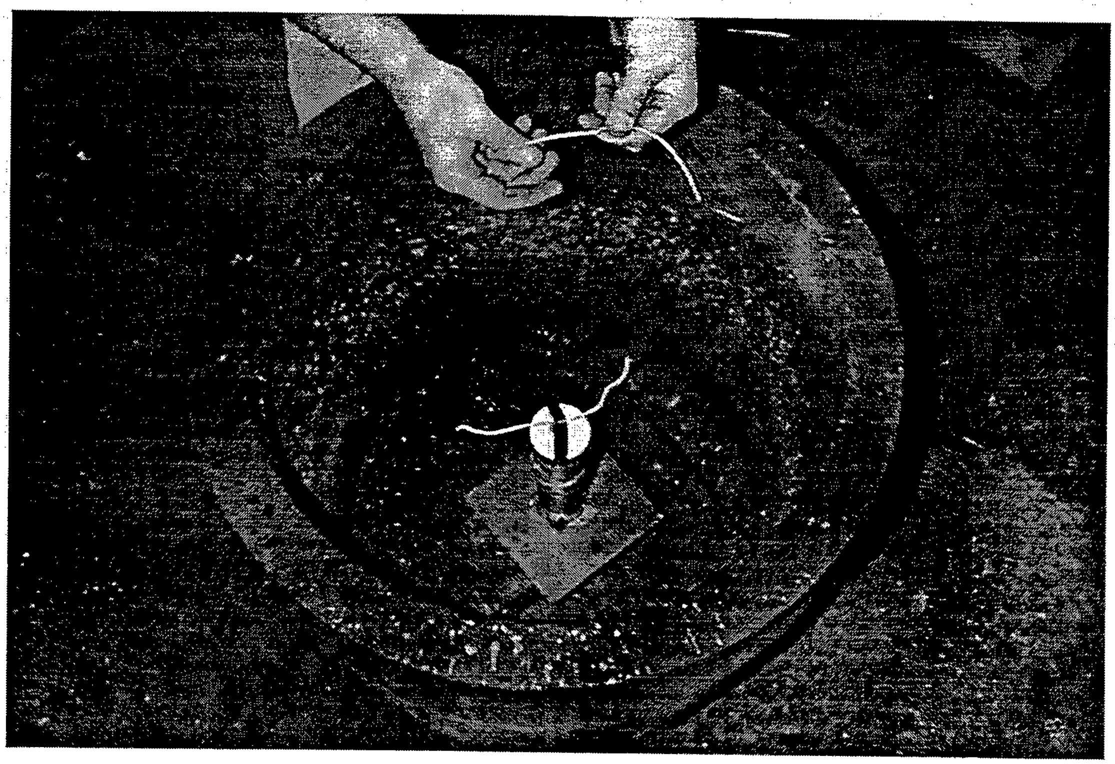


Figure 9
LSG test fixture placed on a 0.375-in. thick witness plate

APPENDIX
DETAILED TEST DATA

LARGE SCALE GAP TEST:

Performed By: Dr. Brian Fuchs, Gerard Gillen, Bob Lateer

LOT # DAZ97G001-002 Date of Test: 4 Sep 98
Density Average: 1.495 gm/cc

SHOT	GAP	RESULT	REMARKS
1	2.000in	Go	
2	2.150in	No-Go	
3	2.080in	Go	
4	2.120in	No-Go	N+1
5	2.100in	Go	
6	2.090in	Go	
7	2.110in	Go	N
8	2.110in	Go	N
9	2.120in	Go	N+1
Designation	IV 2 Shots @ N+2	2.130in	
10	2.130in	No-Go	
11	2.130in	Go	

50% point = N+1 ½ 2.125 in

LOT # LS-5-137 Date of Test: 20 Jul 98
Density Average: 1.475 gm/cc

SHOT	ITEM NO.	GAP	RESULT	REMARKS
1	10	1.500 in	Go	**
2	1	2.000 in	Go	
3	2	2.500 in	No-Go	
4	3	2.250 in	No-Go	
5	4	2.100 in	No-Go	N+1
6	5	2.050 in	Go	
7	6	2.070 in	Go	
8	7	2.090 in	Go	N
9	8	2.090 in	Go	N
10	9	2.100 in	Go	N+1
Designation	IV	2 Shots @ N+2	2.110in	
11	11	2.110 in	No-Go	
12	12	2.110 in	Go	

50% point = N+1 ½ 2.105 in

**Fired such that the high density pellet (J) was fired down towards witness plate

THERMAL STABILITY:

Test Performed: 48 hour Thermal Stability
Performed By: Dr. Brian Fuchs

LOT # DAZ97G001-002
Date of Test: 18 Sep 98

Initial Weight TNT:	131.3664 gm
Post Test:	131.1614 gm
TNT Weight Loss:	0.2050 gm

LOT # LS-5-137
Date of Test: 4 Aug 98

Initial Weight TNT:	140.1173 gm
Post Test:	139.7184 gm
TNT Weight Loss:	0.3989 gm

VACUUM THERMAL STABILITY:

Test Performed: Vacuum Stability at 100°C for 40 hours
Performed By: Keith Rowe
Method: MIL-STD-286C, Method 403.1.3

REPORT NO. EWD 62-98/S, 16 Sep 98
LOT # DAZ97G001-002

Gas at STP: .23 ml
Conclusion: Stable

REPORT NO. EWD 61-98/S, 16 Sep 98
LOT # LS-5-137

Gas at STP: .23 ml
Conclusion: Stable

DIFFERENTIAL SCANNING CALORIMETER (DSC) & MOISTURE WEIGHT PERCENT:

Performed By: Dr. Tung-Ho Chen
Date of Tests: 11 Sep 98

The available comparative results are summarized below:

LOT #	Moisture, Wt. %	DSC, 5 C/min. Max. Exo., C*	M.P., C**
DAZ97G001-002	0.031 +/- 0.007	308.75	81.62
LS-5-137	0.025 +/- 0.005	306.23	81.93

* Maximum Exothermic Temperature in Degrees C
** Melting Point in Degrees C

The moisture contents are identical within the experimental errors and are well within the specification value (0.1 % max), while the differential scanning calorimeter values are essentially identical within the experimental errors.

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